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Intercropping of *Zingiber officinale* Var. *Amarum* on teak silviculture in Karangduwet, Paliyan, Gunung Kidul Yogyakarta

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Abstract. This research aims to evaluate the influence of silvicultural technique (combination between singling and teak pruning) and ginger fertilizing in agroforestry plants productivity. Factorial random complete block design was used as experimental design, using three factors, that are teak pruning intensity, teak singling, and ginger fertilizing. Pruning intensity were P0 (without pruning) and P1 (60% pruning intensity), singling were S0 (without singling) and S1 (singling of teak coppice), and fertilizer intensity were J0 (without fertilizer) and J1 (5 ton/ Ha of compost + 525 kg/ha of NPK). The research was conducted in teak private forest in Karangduwet, Paliyan, Gunung Kidul. The applied silvicultural technique system was clear cutting with coppice/sprout regeneration. Teak trees were the result of teak coppice in 2009 (6 years old). Result showed that singling gave significant influence to teak diameter growth (1.67 cm/1.5 year), while fertilizer gave significant influence to teak diameter (1.71 cm/1.5 year) and height growth (1.16 m/1.5 year). Moreover, teak pruning and ginger fertilizing gave significant influence to the resulted ginger wet weight. In this research, best ginger production (121.53 gram/clump) was found in the application of fertilizer combined with intercropping of pruned teak.

1. Introduction

To fulfil their needs, farmers require private forest as source of wood, food, medicine, and other non-timber products. These kinds of product able to increase farmer's income and also improve the environmental quality. However, in Java, the land productivity is relatively low due to factors such as limited land ($\pm 0,25$ ha), farmer capital, and low application of agroforestry technology. The improvement of private forest land can be conducted by implementing multiple product, i.e. long-term product (wood) and short-term product such as non-timber forest products (NTFPs)

Ginger or *Zingiber officinale* Var. *Amarum* as (NTFPs) having potential to be planted by using intercropping technique in teak (*Tectona grandis*) silviculture in order to increase farmers income. Ginger can be planted under main tree with less light intensity. Based previous study [1], 25% of treatment for main tree showed highest result on plant's production and biomass than the others (75%



of density and open space or 5% of density). The 87-92% of light intensity produces more teak than 50-77% and 70-100% of light intensity [2, 3].

Under teak canopy, the growth of ginger would be hold, therefore it requires advance research to find optimal teak age that could support the ginger plantation [4]. Intercropping ginger + turmeric in 1:1 row ratio produced ginger 73.8 q/ha [5]. Ginger rhizome production was viable financially without inorganic fertilizer during second cropping season within and outside plantation (B/C=1.02, 1.09) respectively. For that, ginger could be raised profitably under teak canopy [6].

Most of farmers in Gunung Kidul Yogyakarta are having private forest for teak plantation due to its wood economic value. Under open area (more light's intensity) in private forest, plant such as corn, ground nut, cassava, and etc are commonly planted. Teak trees were planted around the private forest as border tree, and farmers do not plant under teak trees with high density of tree canopy. They expect timber as long-term product, not the NTFPs.

Silviculture in agroforestry is aimed to optimize the land utilization under the main tree. Plant growth in agroforestry is influenced by sun lights intensity, soil nutrient, and water. Light intensity in agroforestry system can be treated as follow: 1) eliminated died branches, branch with diseases in order to improve wood quality, 2) manipulated the size and canopy shape for keeping the productivity of biomass and competition with the plants under, 3) pruning in keeping production such as fruits, leaves, branches for firewood, etc [7]. For that, the objective of this study is to evaluate the teak silviculture and ginger fertilizing in intercropping system on plant's productivity.

2. Methodology

This research was implemented in teak private forest in Karangduwet, Paliyan, Gunungkidul Yogyakarta. Its coordinate is 08 01 01, 615" S and 110 29' 49,002" E, 220m high above sea level. The topography is low land (not plateau), hill, and mountains. The average air temperature is 25°C with 1.318 mm of rainfall.

In this research were used existing teak in private forests as the result of reproduction from the trees in 2009 (6-7 years old), compost, and anorganic (NPK). Equipment such as hoes, machetes, cormorant, pruning saws and mine, rope, plastic, bamboo, scales, GPS, luxsmeter, measuring tools, stationery, etc also used. The land was prepared by clean any weed followed with soil cultivation by digging the soil 20-30 cm deep. The soil is reversed from the bottom to the surface. Gingers were planted by space 60 × 40 cm. The basic fertilizer is 5 ton/ha + NPK (525 Kg/Ha) based on the experiment design.

The factorial random complete block design was used as experimental design. The first factor is teak pruning intensity namely P0 (without pruning) and P1 (60% of pruning intensity), second factor is teak singling namely S0 (without singling) and S1 (60% of singling), and the third factor is fertilizer intensity namely J0 (without fertilizer) and J1 (5 ton/ ha of compost + 55 kg/ ha of NPK). There are 8 treatments of factorial combinations namely P0S0J0, P0S0J1, P0S1J0, P0S1J1, P1S0J0, P1S0J1, P1S1J0, and P1S1J1. Each treatment combination was placed randomly in three units of smallest homogeneity unit (block). In total, there are 24 experimental units.

3. Results and discussions

3.1. Teak growth

Result shows that singling has significant effect to growth diameter of the teak, while the application of fertilizer (fertilizing) has significant effect on teak diameter and height (Table 1). Moreover, the diameter and height average between treatment combination is shown in Table 2.

Table 1. Variance analysis on the influence of pruning, singling, and fertilizing on teak diameter and height.

Treatment	Diameter (cm)		Height (m)	
	F Cal	Significance	F Cal	Significance
Pruning	0.723	0.396ns	0.008	0.929Ns
Singling	14.686	0.000*	0.931	0.335Ns
Fertilizing	20.684	0.000*	7.048	0.008*
Pruning * Singling	0.025	0.874ns	0.010	0.922Ns
Pruning * Fertilizing	0.726	0.395ns	0.090	0.764Ns
Singling * Fertilizing	0.513	0.474ns	0.350	0.555Ns
Pruning * Singling * Fertilizing	1.687	0.195ns	0.013	0.908Ns

Table 2. The diameter and height of teak after treatment

Treatment	Diameter (cm) /1,5 years	Height (m)/1.5 years
P0S0F0	0.97	0.90
P0S0F1	1.48	1.12
P0S1F0	1.47	1.00
P0S1F1	1.77	1.19
P1S0F0	1.10	0.85
P1S0F1	1.48	1.16
P1S1F0	1.31	1.01
P1S1F1	2.17	1.19

Based on previous study, pruning give many advantages on stem straight and diameter growth of *Acacia mangium* [8]. Pruning can improve the activity of plant's photosynthesis which is in line with the improvement of nitrate reduction activity so that the NH_4 in leaves is getting low [9]. The improvement of photosynthesis is because the leaves are often functioned under its photosynthesis maximum capacity. When the leaves area was decreased due to pruning activity, the remain leaves will increase the photosynthesis capacity [10]. The highest process of photosynthesis was happened on the top of canopy when compared with the bottom, therefore when bottom part was pruned the sun light intensity around the plants will improve the total photosynthesis [11].

Without singling on teak coppice, the main stem can be more than one. It will cause competition between several stems then make low velocity on stem growth. Pruning can improve photosynthesis as the leaves area and light efficiency improvement [12]. The moderate and heavy thinning of teak yielded highest percentage of heartwood volume (25 to 30% of total stem volume) [13]. Intensive thinning has a positive effect to the stem formation even at young stages, producing trees with desired DBH/total height proportions, and wood biomass quality [13, 14]. Close space between plant reduce the diameter at the next age but not significantly affect to the volume in each hectare and plant's basic area [15].

3.2. Ginger production

Based on variance analysis in Table 3, shows that combination of pruning with fertilizing gives significant result on ginger biomass. While the average among treatments were shown in Table 4.

Table 3. Variance analysis on pruning, singling, and fertilizing on ginger biomass

Treatment	Wet Weight of Ginger (gram)	
	F Cal	Significance
Pruning	10.664	0.001*
Singling	0.605	0.437ns
Fertilizing	44.943	0.000*
Pruning * Singling	4.839	0.029*
Pruning * Fertilizing	3.683	0.056ns
Singling * Fertilizing	0.420	0.518ns
Pruning * Singling * Fertilizing	2.430	0.120ns

The highest ginger production was in P1S0J1 (121,3 gram/clump) and the lowest is P0S0J0 (62,20 gram/clump). The ginger productions in the open space with fertilizing and non-fertilizing treatment were 68 gram/clump and 72.7 gram/clump. The teak pruning and fertilizing were influenced by teak production. It shows by the combination between teak pruning and ginger fertilizing on intercropping that produce the heavier ginger (121,53 gram/clump) as shown in Table 4. Pruning will increase light intensity to reach soil surface and reduce tree transpiration [12]. Plant's spacing and pruning can influence the shape of canopy, tree structure, and micro climate condition [12, 16].

From the previous study [17], it is concluded that shading gives significant influence to red ginger growth and biomass. Shading can reduce the main light that is active on photosynthesis and reduce the net assimilation [18]. Photosynthetate that is kept inside the storage will reduce the tuber mass [19]. The improvement of chlorophyll B where it is higher than chlorophyll A made light's energy becomes more efficient for photosynthesis. However, it cannot as fast as tuber biomass reducing [20].

Table 4. Production of ginger biomass on teak silviculture treatment

Treatment	Ginger Productivity /Wet Weight (Gram/clump)
Ginger monoculture + nonfertilizer	68.00
Ginger monoculture + fertilizer	72.70
P0S0J0	62.20
P0S0J1	80.13
P0S1J0	64.57
P0S1J1	90.93
P1S0J0	71.40
P1S0J1	121.53
P1S1J0	67.83
P1S1J1	97.53

Land characteristics on planting site are low soil fertility level, rocky soil and limited water. These characters become an obstacle factors for tree plantation and agriculture. Rehabilitation efforts require a specific agroforestry technology and research for prevent degraded land, aim to improve land productivity. The technology is covering the land preparation technique, soil cultivation technique, fertilizing input, pruning and singling, selection on plants for soil fertilizer, and selection on plants that can life in less water condition. Selection on under tree plantations should consider their ability to life in dry condition and limited water. Plantation on degraded land in forest area was depended on rainfall. Therefore, under tree plantation should be fit with this condition. Moreover, water supply which is depend on rainfall in study location (Figure 1) could be one factor need to be considered. These mentioned factors were predicted to cause low ginger productivity in this study.

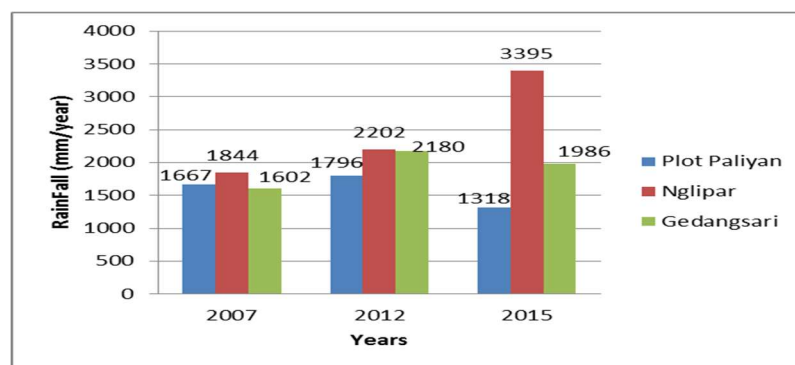


Figure 1. Rainfall in Paliyan sub-district as ginger site plot

4. Conclusion

Singling/stem reducing treatment in coppice system gave significant different on diameter growth of stand cut remain. Fertilizing treatment gave significant different on diameter and height growth of teak. Teak pruning and ginger fertilizing treatment gave significant different on ginger productivity, however low rainfall and hard soil condition caused low ginger productivity than those in other areas.

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